BRIEF RESEARCH COMMUNICATION

Echocardiographic Assessment of Pericardial Effusion Size: Time for a Quantitative Approach

Guidelines for the transthoracic echocardiographic (TTE) assessment of pericardial effusion size rely on linear measurements of the largest width of the effusion at end diastole.[1] Using this system, effusion sizes are graded as small (<10 mm), moderate (10-20 mm), or large (>20 mm). This classification system is subject to potential errors due to variations in heart size, shifts in fluid location during the cardiac cycle, and the highly asymmetric nature of many effusions. Guidelines do not specify which view to use for measurements or how to deal with asymmetric fluid collections. There is limited research on using volumetric approaches to estimating pericardial effusion size.[2-4] We hypothesized that a quantitative assessment of pericardial effusion volume would be superior to conventional linear measurements of effusion size. We compared the two approaches to the actual volume of the effusion determined at the time of pericardial drainage.

METHODS

We retrospectively analyzed patients from January 2013 to June 2017 who underwent a pericardiocentesis or a pericardial window and had a TTE <48 hours before drainage. Each patient also had an intraprocedural TTE that demonstrated complete or near complete resolution of the effusion. Linear measurements of maximum effusion width were measured in both the parasternal long-axis and short-axis views at end diastole. Volumetric estimates of pericardial fluid were made from either the apical four-chamber or subcostal four-chamber view with the best visualization of the complete pericardial and epicardial borders. Pericardial effusion volume was estimated by individually tracing the pericardial and epicardial borders, resulting in two volumes calculated by the method of disks. Effusion volume was calculated by subtracting the heart volume from the total volume. Examples of tracings from each view are shown (apical four-chamber view in Figure 1A or the subcostal view in Figure 1B). Epicardial fat was included as part of the heart volume. Each measurement was completed twice, one with the best view of the heart and effusion borders without regard to the cardiac cycle and another at end diastole. Measurements of effusion size were compared to the total volume drained using linear regression analysis (Figure 1C). Measurements were performed by two echocardiographers (D.M.D., S.E.L.) blinded to the drainage results.

RESULTS

From the initial data set, seven patients were excluded due to poor visualization of the pericardial border (examples in Supplemental Figure 1) and nine due to incomplete drainage of the effusion. The final cohort included 126 patients. The mean time from the TTE to drainage was 20.4 hours. A higher percentage of studies (68%) had better visualization of the effusion borders in the subcostal view when compared with the apical four-chamber view. Effusion volume by the method of disks showed a strong correlation with actual volume drained (Figure 1C, $r = 0.826$, $P < .001$). Linear measurements of effusion width from the parasternal long-axis and short-axis views did not correlate as well ($r = 0.665$ and 0.654, respectively). The coefficients of variation for intra- (D.M.D.) and interobserver (S.E.L.) measurements ($n = 25$) were 0.91 and 0.89, respectively. Almost all of the effusions had calculated and actual volumes >500 mL.

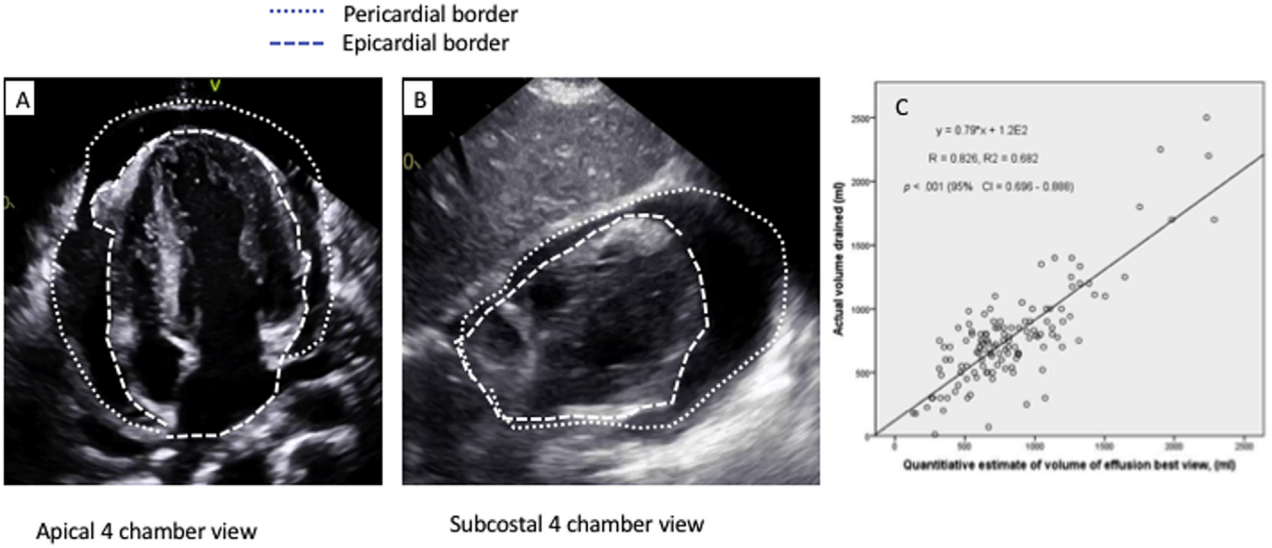

Figure 1 **(A)** Apical four-chamber image depicting quantitative assessment of effusion volume. The *dotted line* delineates the pericardial border, and the *dashed line* shows the epicardial border. Using the method of disks in this patient, the total volume was calculated to be approximately 1,456 mL, and the heart volume was 642 mL, leaving the estimated effusion volume to be 813 mL. The actual volume drained at pericardiocentesis was 850 mL. Cine images are shown in Supplemental Figure 1. **(B)** Subcostal four-chamber image from a different patient depicting quantitative assessment of effusion volume. The *dashed line* indicates the epicardial border and the *dotted line* indicates the border of the pericardial effusion. The total volume was calculated to be approximately 1,813 mL, and the heart volume was 927 mL, leaving the estimated effusion volume to be 886 mL. The actual volume drained at pericardiocentesis was 850 mL. Cine images are shown in Supplemental Figure 1 **(C)** Correlation between pericardial fluid volume calculated using the method of disks and the actual volume drained during pericardiocentesis ($r = 0.826$, $P < .001$).

Allan L. Klein, MD, FASE, served as guest editor for this report.

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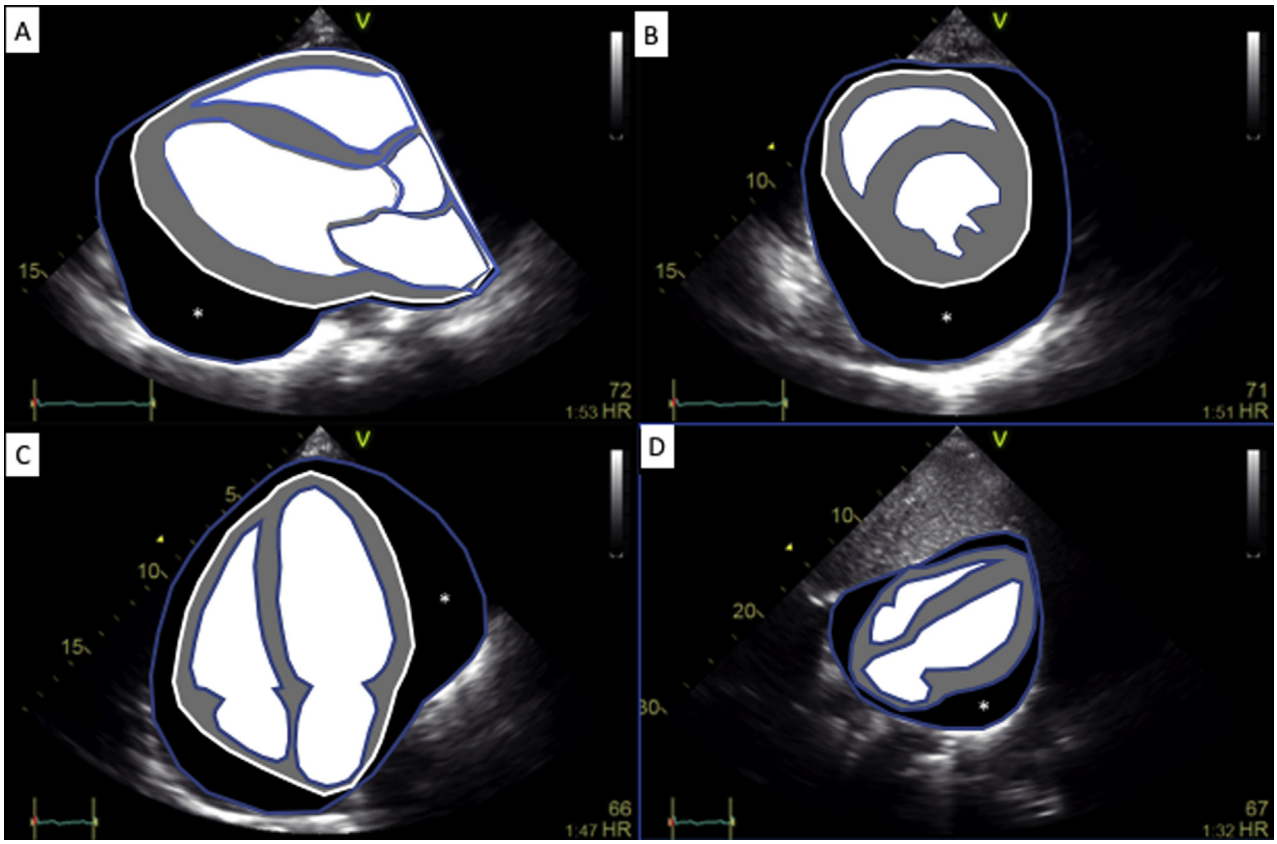

Figure 2 Cartoon (overlaying actual images) illustrating the potential pitfalls of using a single linear dimension to quantify effusion size when fluid collection is asymmetric. In this example, four different views are shown from the same patient: **(A)** parasternal long axis, **(B)** parasternal short axis, **(C)** apical four-chamber, and **(D)** subcostal four-chamber. Because the effusion (denoted by an *asterisk*) is highly asymmetric, a volumetric approach is superior to the use of any single linear dimension. In this example, the apical four-chamber view best shows the overall volume of the effusion and would be the optimal view for quantifying effusion volume.

Limitations

The main limitation is not having the entire pericardial volume visible in one view (Supplemental Figure 1). However, a better approach is to obtain views that do not cut off any portions of the effusion (Figure 2). This has not been done routinely in the past but is relatively easy to do. The current data do not allow us to establish volumetric criteria for small, moderate, and large effusions since we only have confirmation of actual volume in those who underwent pericardial drainage. However, since almost all of the patients had a pericardial volume close to 500 mL or greater, this may be a reasonable starting point for defining large effusions. We suggest cutoffs of 100 mL to separate small from moderate effusions. Importantly, the decision to perform drainage depends on the clinical situation as well as the size of the effusion.

CONCLUSION

There is a strong, positive correlation between quantitative measures of pericardial effusion volume using the method of disks and actual effusion volume drained. The volumetric measurement was highly reproducible and correlated better with actual volume of effusion than linear dimensions or qualitative estimates. The subcostal view was generally better for visualizing the entirety of the pericardial effusion borders and measuring volumes compared with the apical four-chamber view. The timing of measurement relative to the cardiac cycle does not matter since the pericardial fluid is noncompressible. TTE has advantages over computed tomography[4] or magnetic resonance imaging[5] since it is precise, sensitive, and promptly available and requires no radiation or contrast material. Adoption of a quantitative approach to grading effusion sizes could aid in both clinical decision making and future research efforts. Further education about proper imaging in the apical and subcostal views so that the entire effusion can be visualized may help to refine this technique and may help to standardize the care of patients with pericardial effusions.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.echo.2019.08.019.

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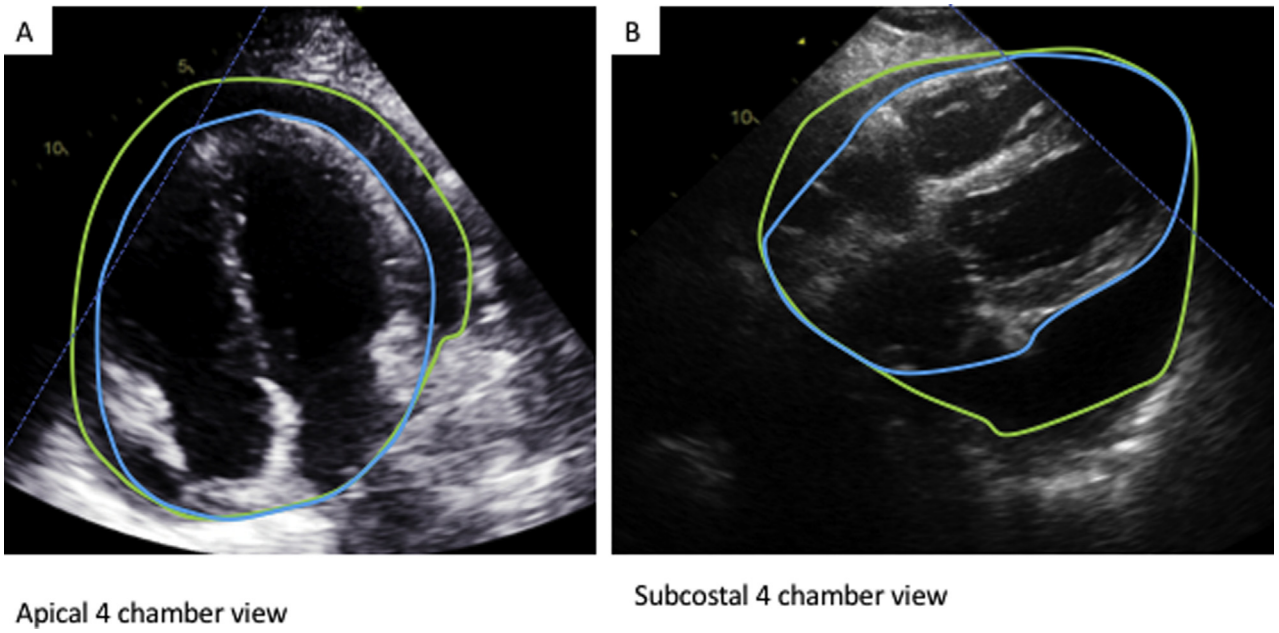

Supplemental Figure 1 Examples of suboptimal images for quantifying effusion volume due to dropout or inadequate field of view causing the effusion or the heart volume to be cut off (indicated by *dotted lines*). **(A)** Apical four-chamber view with the portion of the effusion near the right ventricle is not well seen. The total volume was calculated to be approximately 1,241 mL, and the heart volume was 902 mL, leaving the estimated effusion volume to be 339 mL. The actual volume drained at pericardiocentesis was 460 mL. **(B)** Subcostal view depicting suboptimal viewing of the entire pericardial effusion. The border of the pericardial effusion and the epicardial border are cut off near the apex. The total volume was calculated to be 3,334 mL, and the heart volume was 2,001 mL, leaving the estimated effusion volume to be 1,333 mL. The actual volume drained at pericardiocentesis was 2,250 mL. This example also shows the highly asymmetric nature of an effusion with much larger accumulation near the lateral left ventricular free wall.